Identifying Blue Mussel (*Mytilus edulis)* Resource in Coastal New Hampshire

Final Report

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26 June 2013

Introduction: The NH Department of Environmental Services maintains a Geographic Information Systems (GIS) file on historical and current molluscan shellfish resources in tidal waters. As new or updated information is made available by various coastal agencies and stakeholders, the data, metadata, and supporting information/reports are incorporated by NHDES into shapefile updates. The data are used by multiple state agencies for a number of resource management initiatives, such as tracking changes in shellfish bed occurrence over time, identification of restoration opportunities, and aquaculture management.

Prior to 2013, most of the resource delineation in the GIS file was focused on the occurrence of American oyster and softshell clam. Information on the occurrence of other species, such as blue mussels, was rather limited, even though this species is present throughout coastal New Hampshire. Updated information on the occurrence of this shellfish species is important to effective resource management and sound siting of future aquaculture operations in estuarine environments.

Objective: To identify and delineate molluscan shellfish beds within the state tidal waters of New Hampshire, focusing on blue mussels. A secondary objective is to develop and test a methodology to quantify mussel bed density. As time and resources allow, delineation of shellfish resources other than blue mussels will be pursued.

Methodology: Historical data, current data, and personal observation on the locations of shellfish beds within the tidal waters of New Hampshire were compiled from several sources, including NHDES, NH Fish and Game, the University of New Hampshire, Normandeau Associates, and The Nature Conservancy. Locations of shellfish beds primarily within Great Bay Estuary, Hampton/Seabrook Harbor, Little Harbor/Back Channel, and the Atlantic Ocean coastline were mapped from the existing GIS shapefile using ArcGIS 10.1. The aforementioned agencies reviewed the maps and made recommendations for additional locations to explore, based on historical data or personal observation. The focus of the project was on the occurrence of blue mussels. A total of 12 current beds were identified for the blue mussel with an additional 24 locations proposed for investigation based on historical data or personal observation. These 36 locations became ‘potential sites’ and were examined to determine if resource was present, and ranked according to densities.

Between April 2013 and June 2013, a primary survey was conducted at 32 of the 36 sites. The primary survey consisted of a shoreline walk or boat ride conducted at low tide. Sites were visited in order of priority: sites known to have current or historical resource were visited first, followed by proposed sites based on personal observation, followed by sites identified as having potential habitat. During the primary survey, the surveyor walked the entire area of the potential site to identify resource presence. If resource was not present, location and date visited were noted and density was indexed as 'not present.' If resource was present, the surveyor evaluated approximate abundance of the bed and assigned a non-quantitative ranking of very low, low, low-medium, medium, medium-high or high. Only one density ranking was assigned per site, even if densities within the bed varied. At sites with high variability, the density representing a majority of the bed was selected. Due to subjectivity, only one surveyor assigned the rankings, and these rankings were based off of personal observation and site comparison.

Additionally, the approximate perimeter of each bed was delineated by taking waypoints using a Garmin 78sc unit. Waypoints were created at boundaries where resource was found. Waypoints were taken approximately every ten feet in areas with dense resource and taken when more than two mussels were observed together in scarcer areas. These waypoints were documented in a Microsoft Excel Spreadsheet and imported to ArcGIS 10.1. Polygons of each bed were created by outlining the waypoints using the "create feature" tool in ArcGIS 10.1. If waypoints of perimeters could not be obtained (often due to conditions within the site), boundaries were visually identified or aerials were used to identify potential habitat boundaries. This provided a rough perimeter and approximate area of each bed. Occasionally, two beds were created at one potential site. Figures 1-4 illustrate bed locations.

Figure 1: Blue Mussel Resouces in/near Little Harbor

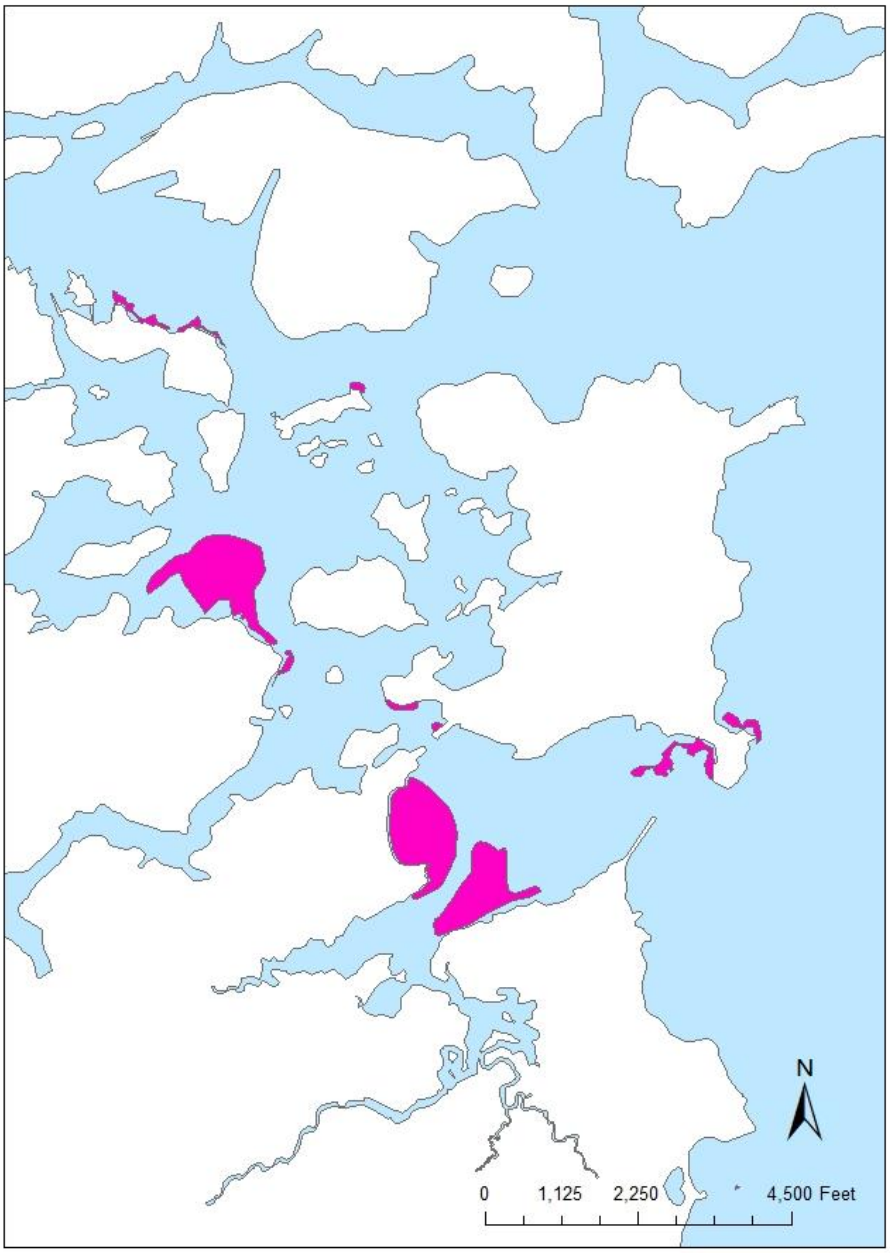


Figure 2: Blue Mussel Resouces Rye Harbor, Rye Ledge

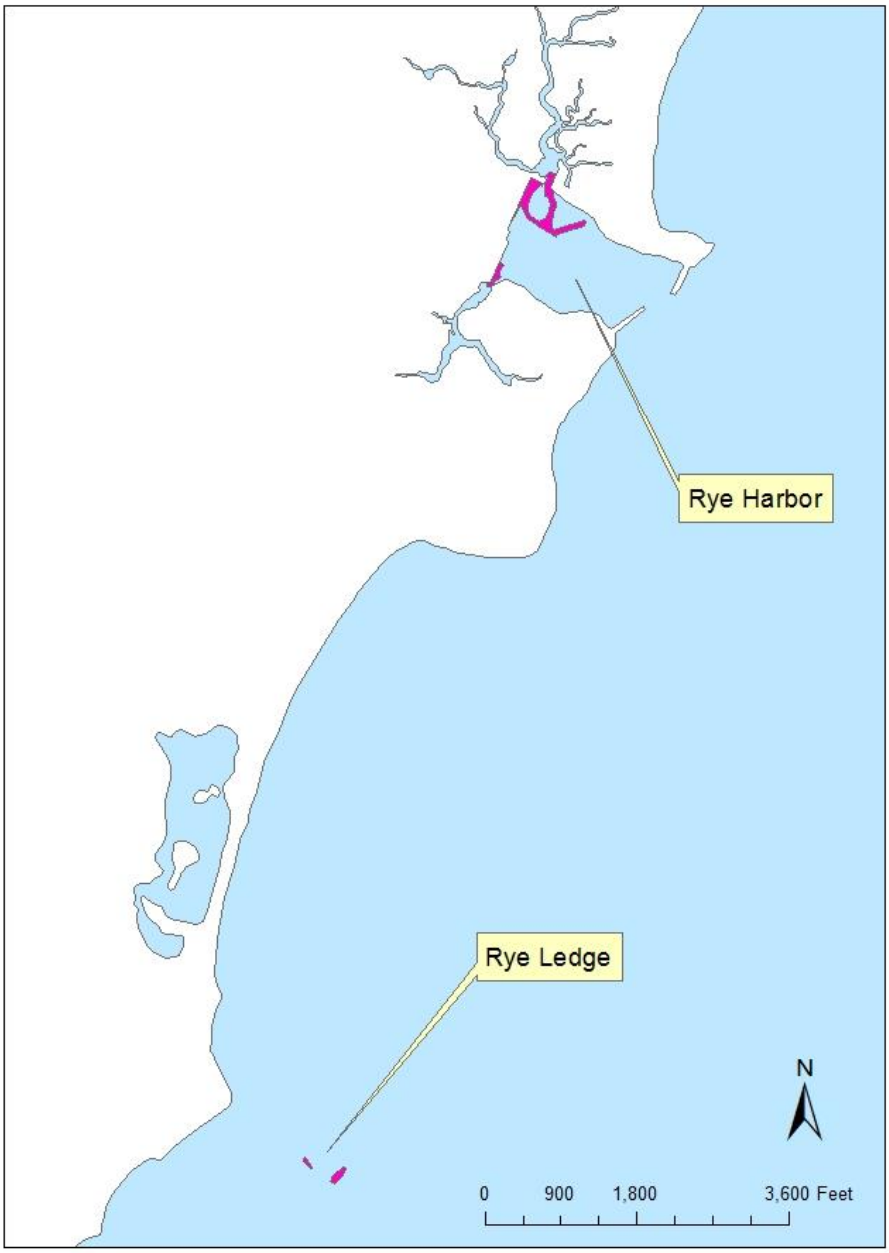


Figure 3: Blue Mussel Resouces in Hampton/Seabrook Harbor

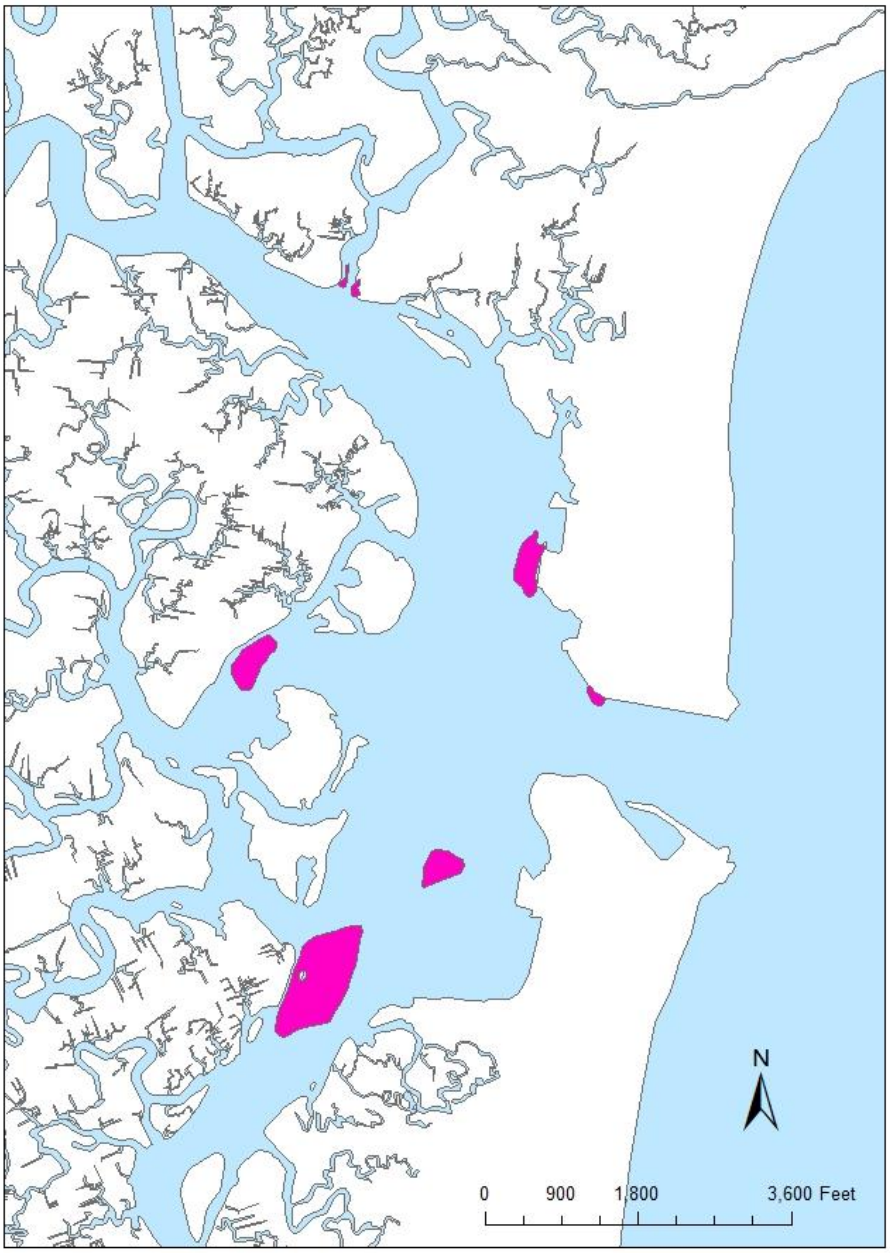
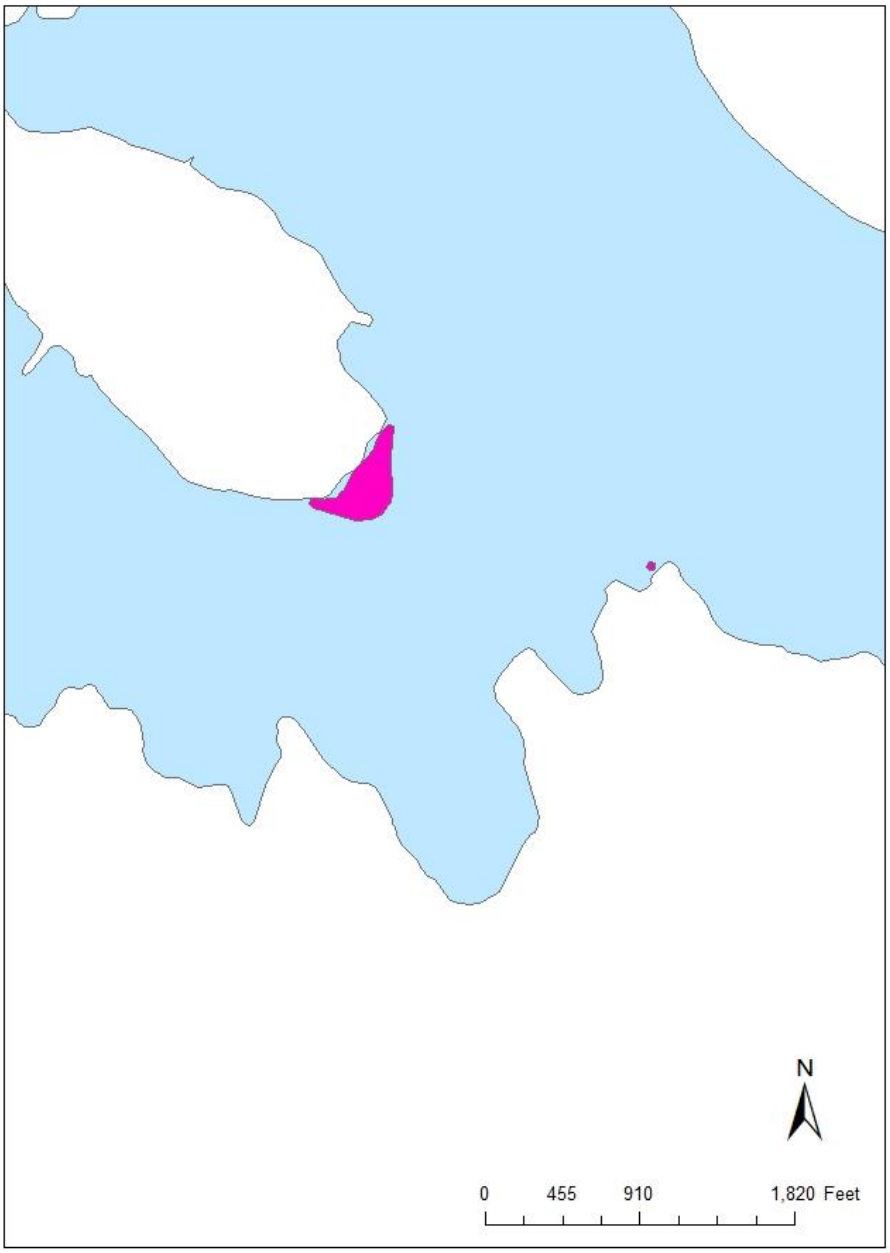


Figure 4: Blue Mussel Resouces at/near Dover Point



Gathering density data was a component of the shellfish delineations for two reasons. In particular, quantifying density provides a general sense of availability of the resource and may also help to define viable beds. This could also be used to create a more concrete abundance ranking system. Secondly, it is thought that measuring densities would clarify what numbers constitute the perimeter of a bed. In an effort to gather accurate quantitative data on bed density, a transect study was developed. The transect study occurred after the primary survey was completed, and a data sheet was created for this survey (Appendix I).

The sites surveyed for the transect study were visited at low tide. A pre-existing point on the northwest border of the bed was generated using ArcGIS 10.1 (determined from the intersection of the northern-most and western-most point) and entered into the Garmin 78sc to aid surveyors in locating the start point in the field. A long transect tape (200 feet) and short transect tape (100 feet) were brought into the field to create a grid-shaped survey area. Using the 200ft tape, a 60 meter (m) line was run to create a boundary in north-south or east-west orientation (this was predetermined by the shape of the shellfish bed). The 60m line was fixed to the predetermined start point using a rock, and a compass bearing was used to ensure accuracy of direction. Once set, the 60m line remained in place for the entire survey, and waypoints were taken at 0m and 60m marks. From the 100ft tape, a 30m line was used to intersect the 60m line to start the grid-shaped survey. The 30m line was moved along the 60m line by increments of a set distance (in meters), and this increment was chosen using a random number table (http://teorica.fis.ucm.es/ft8/tablern2.pdf). For this project, the number 6 was selected, and the 30m line was moved every 6m down the 60m line from 0m to 60m. The 30m line was set perpendicular to the 60m line and towards the tidal water. A compass was used to calculate the 90 degrees between the two lines to ensure consistency. Waypoints were taken at the start of the 30m line once surveying began, and waypoints were taken at the end of the 30m line after sampling was completed. Waypoints were taken in this order to avoid miscalculations due to movement of the line during the survey. Using the same random number table, a one digit number was selected for quadrat placement (the number 5 was randomly selected for this project). Quadrats were placed on the right side of the 30m line to maintain consistency. Original quadrat size was 0.5 m^2, but was later increased to 1 m^2 after the initial (and only) survey. These quadrats were used to enumerate shellfish within the given area, and moving the substrate within the quadrat was permitted to get accurate counts. Only the shellfish species specified at the start of the survey were enumerated--all other shellfish species were documented within the comments field of the data sheet. The Shellfish Transect Survey SOP can be found in Appendix II.

The transect method was conducted once at the Rye Ledge Bed 1, and 0.5 m^2 quadrats were used. The quadrats were enlarged to 1 m^2 after this initial survey in order to increase effectiveness. However, due to time constraints and weather conditions, no other transect survey was completed, and the effectiveness of the 1 m^2 quadrats was not evaluated. It was also noted that due to complex substrate, the transect study may be best used in sites with uniform substrate. The transect study had two major objectives: the first was to provide a general sense of resource availability, and the second objective was to identify

if certain densities may indicate a natural perimeter. Shellfish beds are often proximal, and boundaries may be difficult to identify. Measuring density may help identify perimeters, distribution behavior, and resource availability, and additional transect studies should be attempted.

Results:

Mussel Bed Delineations: Of the total 36 potential sites, a primary survey was conducted at 32 sites. Of the 32 sites, five sites surveyed had no resource present ('not present'), two sites were ranked at 'very low' densities, six sites had 'low' densities, four sites had 'medium-low' densities, ten sites had 'medium' densities and five sites had 'medium-high' densities. No sites surveyed exhibited relatively high densities, and no relatively large beds (in terms of area) were discovered. Bed densities were assigned numerical values ranging from 0 to 6 (not present being 0 and high being 6). The use of numerical rankings was intended for future symbology illustration within ArcGIS. Actual density numbers would be derived from the transect survey.

A total of 19 polygons were created during the project, with 13 of these polygons representing previously non-delineated beds. The remaining six polygons were created to modify existing polygons (bed area decrease or a boundary shift). An additional five existing polygons were imported from the 2012 shellfish bed shapefile with no changes, per the findings of field surveys. Thus, a total of 24 polygons comprise the 2013 blue mussel delineation. Polygons delineating blue mussel beds from previous shapefiles were updated to 'not current' status so that the 2013 blue mussel delineation remains the most current.

Transect Surveys: Two attempts were made to conduct transect surveys. The first attempt occurred at Rye Ledge Bed 1, and the survey was almost completed. The second attempt occurred at the Back Channel Bed and could not be started due to weather-related conditions. Through the initial trial at Rye Ledge Bed 1, it was discovered that the transect survey is time-intensive, and several other changes were made to create a more effective survey. The survey at Rye Ledge Bed 1 began about a half hour before low tide, and the survey could not be completed in the time allotted. It is suggested that setup occurs 1.5-2 hours before low tide to provide a sufficient time to complete the field work. Additionally, the size of quadrat used increased from 0.5 m^2 to 1 m^2 after findings at Rye Ledge show insufficient data. However, future attempts to complete the survey may increase the availability of quantitative data.

American oyster and softshell clam surveys (primary and transect) were not completed during this project. If there was an indication that the resource existed at blue mussel survey sites, these records were added to the project's excel spreadsheet. The records serve to provide evidence of resource presence when primary surveys are eventually conducted. With the exception of the transect survey, using a similar protocol to above may serve to update these delineations in a timely fashion.

Summary: The present study focused on improving the characterization of blue mussel resource in coastal New Hampshire. Field surveys of bed area extent suggested that five of the 11 previously identified beds remained the same in size, while the other six required boundary adjustments. Field surveys revealed an additional 13 blue mussel beds that had not been included in previous GIS shapefiles. The field surveys also included a qualitative assessment of mussel bed density. A field protocol for quantatative assessment of bed density via transect surveys was drafted and tested on one blue mussel bed.

Appendix I
Shellfish Transect Data Sheet

Shellfish Delineation Sampling Blue Mussel					
Sample ID: 2013_____			**Location:_____**		
Start Coordinates:_____			**End Coordinates:_____**		
Samplers Initials:_____			**Date: _____ Time:_____**		
TRANSECT ___	**COORDINATES:_____**		**TRANSECT ___**	**COORDINATES:_____**	
Quadrat #	**Shellfish count**	**Comments**	**Quadrat #**	**Shellfish count**	**Comments**
**** Record other species/substrate in comments**					

Add additional transects as needed for specific site conditions.

Appendix II
Shellfish Transect Standard Operating Procedures (SOP)

Materials:

***2 x 100 ft measuring tapes**	***1 x 200 ft measuring tape**
***2 x 1 m^2 Quadrats**	***Stakes**
***Data sheets**	***GPS**
***Clipboard**	***Pencils**
***Compass**	***Bucket**

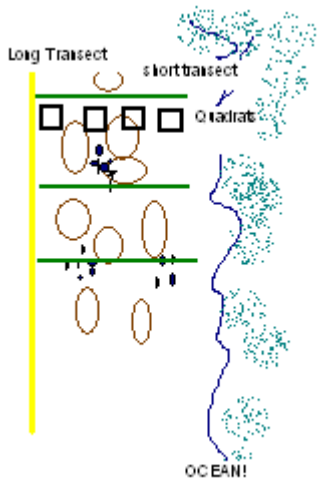
****** Designed for 2 teams of 2 people******

Methods:

The transect survey is best conducted after an initial survey is done at a potential site, so that the general bed shape is known and some waypoints have been collected from the site. The survey should be started no later than 1.5 hours before low tide to allow for sufficient time for both the setup and the survey. Establish a start point to place a 200ft measuring tape by calculating the intersection of the northern-most and inward points of the bed (based off the perimeter from the initial survey). This point can be generated using ArcGIS, and it should be entered into the GPS to be located in the field. Once in the field, secure the long transect at this point using a rock or stake and run the 200ft measuring tape 60m roughly north-to-south or west-to-east depending on previously determined bed shape (perpendicular transects will run toward tidal water). Using the GPS, record start and end coordinates of the 60m line. Using a random number table (http://teorica.fis.ucm.es/ft8/tablern2.pdf), select a one-digit random number to determine where perpendicular lines will be placed along this 60m line (i.e. if the number chosen is 6, lay the short transects every 6 meters along the 60m transect).

Using a compass, lay the 100ft measuring tape perpendicular to the main transect line for 30 meters. Take start coordinates of the shorter transect (start should be the intersection of the main transect and perpendicular transect) once surveying begins and take coordinates of the end of the 30m transect. Avoid taking end coordinates before surveying is completed, as the line may move. Using a random number table (http://teorica.fis.ucm.es/ft8/tablern2.pdf), select a one digit random number to identify where to place quadrats on the 30m line. Place the top of the quadrat at the selected number (i.e. if every 5m will be assessed, place the top of the quadrat at 0m, 5m, 10m, etc). Assess the quadrat on the right side of the measuring tape. Use 1 m^2 quadrats (the trial used 0.5 m^2 quadrats and resulted in insufficient data collection). The movement of substrate within the quadrat is permitted, as this study serves to identify density of existing resource. Data collection is most efficiently done with two people on one line, allowing one person to record and one to count the shellfish within the quadrats. Make sure to record compass bearing and data on datasheets (Appendix I).

Once a transect survey is completed, data can be entered into ArcGIS. Start with the waypoints from the 60m and 30m lines to determine grid shape. It may be easier to create a line shapefile to enter this information. Using the editing tool, place points along the lines where quadrats were measured. You can enter counts per quadrat in this manner. A point shapefile could also be created in order to superimpose quadrat position and to assign value (the actual counts within the quadrat) to the attribute table. In this way, symbology can be assigned and general density can be shown. This procedure is not set, but worked initially, so modifications are permitted.



Schematic of Transect Survey

Appendix III
Blue Mussel Bed Documentation

ACCESS	LOCATION	BED NAMES	SPECIES	CHECKED?	BED DENSITY	New Polygon?	LOCATION	COMMENTS
WALK	DOVER	Dover Point Bed	BLUE MUSSEL	5/8/2013	MEDIUM	Y	mapped as one bed, see below under gen	little more than coast guard . GPS DOVPT
WALK	DOVER	Dover Point Bed	BLUE MUSSEL	5/16/2013	MEDIUM	Y	sullivan bridge span, may connect to dover pt. all of rocky outcrop. Small bed but high density	GPS HIL. HIL and DOVPT mapped as one bed
WALK	HAMPTON	GREAT BOARS HEAD	BLUE MUSSEL	6/11/2013	n/p	N	did not find resource, although surveyed 1hr after lt. did not check ne of point	no resource found, may go back to check ne corner of ledge.
WALK	HAMPTON	Hampton River Bed	BLUE MUSSEL	5/14/2013	LOW	Y	from the sand bar pt at the mouth of HRM to the normandeau dock	GPS HRM. Very small bands of live mussel in low tide areas, most of area is dead/shell
WALK	HAMPTON	HAMPTON STATE PARK	BLUE MUSSEL				by hampton park jetty	
WALK	HAMPTON	HAMPTON STATE PARK BRIDGE	BLUE MUSSEL	5/14/2013	MED-LOW	N	under hamp-seabrook bridge on hampton side.	GPS HB small band of encrusted mussel in mid tide band
WALK	NEWCASTLE	FORT POINT	BLUE MUSSEL	5/7/2013	LOW	N	NOT ON MAP, BRUCE SUGGESTION . Park unh pier	GPS COASTG
WALK	NEWCASTLE	Fort Stark Bed 1	BLUE MUSSEL	4/30/2013	MED-HIGH	Y	NOT ON MAP, BRUCE SUGGESTION. Park on wild rose rd/fort stark. Small bed but large density	GPS FORTST or FTST. 2 polygons of two beds at this site

WALK	NEWCASTLE	Fort Stark Bed 2	BLUE MUSSEL	4/30/2013	MED-HIGH	Y	NOT ON MAP, BRUCE SUGGESTION. Park on wild rose rd/fort stark. Exists only at low tide, slightly offshore.	GPS FORTST or FTST. 2 polygons of two beds at this site
WALK	NEWCASTLE	Rye-Newcast Bridge Bed 1	BLUE MUSSEL	6/12/2013	MED-LOW	Y	NOT on map, park by pull off by wentworth golf course	VISUAL OBSERVATION, could not access
WALK	NEWCASTLE	Rye-Newcast Bridge Bed 2	BLUE MUSSEL/ CLAM	6/4/2013	MEDIUM	Y	On LH side of Rye/New bridge, starts under bridge piling, runs past condos and towards WC mansion	GPS WBS and WB. Evidence of both bmussel and clam
WALK	NEWINGTON	BLOODY PT?	BLUE MUSSEL	5/16/2013	n/p	N	Saw one live mussel, lots of shell. Possibly a good clam site	GPS BP
WALK	PORTSMOUTH	Back Channel Bed	BLUE MUSSEL/ CLAM	5/30/2013	MED-HIGH	Y	starts to the right of the wwc mansion, runs almost to 2nd ports-newcastle bridge. Curved shape. Potential bed also across on newcastle	GPS BB. Large bed, hard to get perimeter accurately as it is soupy! Whole bed exposed only at neap tide. Gps didn't save points bb1-23 due to low battery so most is approximation except 6 pts by wentworth coolidge mansion. Polygon based on visual estimate
WALK	PORTSMOUTH	PYC Bed	BLUE MUSSEL	5/7/2013	MED-HIGH	Y	by residential parcel, before crossing last bridge into new castle. Where buoy got lost during dye study. Park at portsmouth yacht club	GPS PYC checked again 6/4m, coordinates taken then.

WALK	PORTSMOUTH	Peirce Island Bed	BLUE MUSSEL/CLAMS (VERY VARIABLE)	6/12/2013	MEDIUM	Y	all of PI; starts on peirce by 4tree isl and around island , excludes cliffs on piscataqua river side.	GPS NY (navy yard) . Variable runs from low to very high. Some evidence of juvenile pop as well. Evidence of clam in some sand/muddy areas. Possible resource beyond cliffs on piscat. River side but could not access. WILL include in polygon
WALK	PORTSMOUTH	PRESCOTT PARK	BLUE MUSSEL				by old boat launch and rocks on southern side of park	
WALK	PORTSMOUTH	WENTWORTH COOLIDGE MANSION	BLUE MUSSEL	N/a	LOW	N	Smaller mussels under ascophyllum. Visual observations occurred during sampling for cages. Actual gps taken under wentworth/bb trip (see below)	sample for psp
WALK	PORTSMOUTH	Wentworth Mansion Bed	BLUE MUSSEL/ CLAM	5/16/2013	MEDIUM		went-coolidge bed and up to bridges. Expansive and soupy. Observed by kv and cn by boat	GPS BB (all that were saved, see bb channel note)
WALK	RYE	LITTLE BOARS HEAD	BLUE MUSSEL			N	NOT ON MAP, BRUCE SUGGESTION	no coordinates taken
WALK	RYE	LITTLE RIVER	BLUE MUSSEL	5/2/2013	N/P	N	NOT ON MAP, BRUCE SUGGESTION	no coordinates taken
WALK	RYE	ODIORNE COVE BED	BLUE MUSSEL	5/2/2013	VERY LOW	N	NOT on map, first pull off south of park (petrified forest cove)	GPS 'ODIOR'
WALK	RYE	Odiorne Point Bed	BLUE MUSSEL	4/17/2013	MED-HIGH	Y	GPS OD. LARGE INTACT AREAS, but most Mussels in clumps. Take trails in, starts across from golf course and runs	

							to frost point	
WALK	RYE	PULPIT ROCK	BLUE MUSSEL	4/30/2013	N/P	N	NOT ON MAP, BRUCE SUGGESTION . Across from pulpit tower	GPS 'PULPIT'
WALK	RYE	RYE HARBOR BED	BLUE MUSSEL	6/19/2013	LOW	Y	Under bridge mostly	GPS RH. Along tidal creek and under bridge. Some along rocks by harbor. Good clam spot (lots present)
WALK	RYE	Rye Ledge Bed 1,2	BLUE MUSSEL	4/30/2013	MEDIUM	Y	NOT ON MAP, BRUCE SUGGESTION . LOW TIDE!!	GPS 'RYEL' . 2 polygons of two beds at this site
WALK	RYE	RYE STATE PARK	BLUE MUSSEL	6/19/2013	n/p	N	no resource present	
WALK	RYE	SAGAMORE MOUTH BED	BLUE MUSSEL/ CLAM	5/16/2013	MEDIUM	N	sagamore mouth, across from wentworth bridge. Very soupy! Observed by kv and cn by boat	no polygon drafted because no gps points obtained
BOAT	DOVER	GOAT ISLAND	BLUE MUSSEL			N		
BOAT	HAMPTON	BLACK WATER RIVER BED	BLUE MUSSEL	5/15/2013	MED-LOW	N	WEST BANK INBTWN	GOING TO LEAVE CURRENT 2012 DATA AFTER EVAL. BED WITH LEAST SHELL AND MOST CLUMPS ALTHOUGH PRETTY LOW DENSITY
BOAT	HAMPTON	BROWNS RIVER FLAT BED	BLUE MUSSEL	5/15/2013	LOW	N	KNOWLES IS AND BROWNS RIVER	GOING TO LEAVE CURRENT 2012 DATA AFTER EVAL. MORE SHELL THAN LIVE, MOST LIVE IN LOW TIDE WATERS
BOAT	HAMPTON	Middle Ground Bed	BLUE MUSSEL/ CLAM	5/15/2013	LOW	Y	IN FRONT OF YANK COOP EXTENDS TO CHANNEL MOUTH	GPS HFL. POOR BED, WILL BE DOWNSIZING THE 2012 SHAPEFILE TO FIT NEW ESTIMATED BED. MOST LIVE MUSSEL ON LOAM LIKE SUBSTRATE. CLAM ALSO IN AREA AND PAST LOAM AREAS. BRUCE SUGGESTED LITTLE RESOURCE AT THIS SITE
BOAT	HAMPTON	Tide Mill Creek Bed 1	BLUE MUSSEL	5/15/2013	MEDIUM	N	BOTH SIDES OF MOUTH. MUSSLES ON ROCKY	GPS TMC. GOOD SIZED BED IN TERMS OF LIVE:SHELL. EXTENDED AREA SLIGHTLY IN 2013. 2 polygons of two beds at this site

							SUBSTRATE BOTH SIDES	
BOAT	HAMPTON	Tide Mill Creek Bed 2	BLUE MUSSEL	5/15/2013	MEDIUM	Y	BOTH SIDES OF MOUTH. MUSSLES ON ROCKY SUBSTRATE BOTH SIDES; NEW EXTENSION ON EAST BANK	
BOAT	NEWINGTON	FOX POINT BED	BLUE MUSSEL	5/16/2013	VERY LOW	N	very low resource densities ….2 live mussels found.	GPS FXP
BOAT	RYE	Wentworth countryclub bed	BLUE MUSSEL	6/12/2013	MEDIUM	N	visual obs, decided to leave old data current	
WALK	RYE	Saunders Bed	BLUE MUSSEL	6/19/2013	MED-LOW	Y	By old saunders, primarily under bridge	GPS RY, small bed but good number